National Renewable Energy Laboratory

Status on Developing IEEE Standard P1547 for Distributed Resources Interconnection

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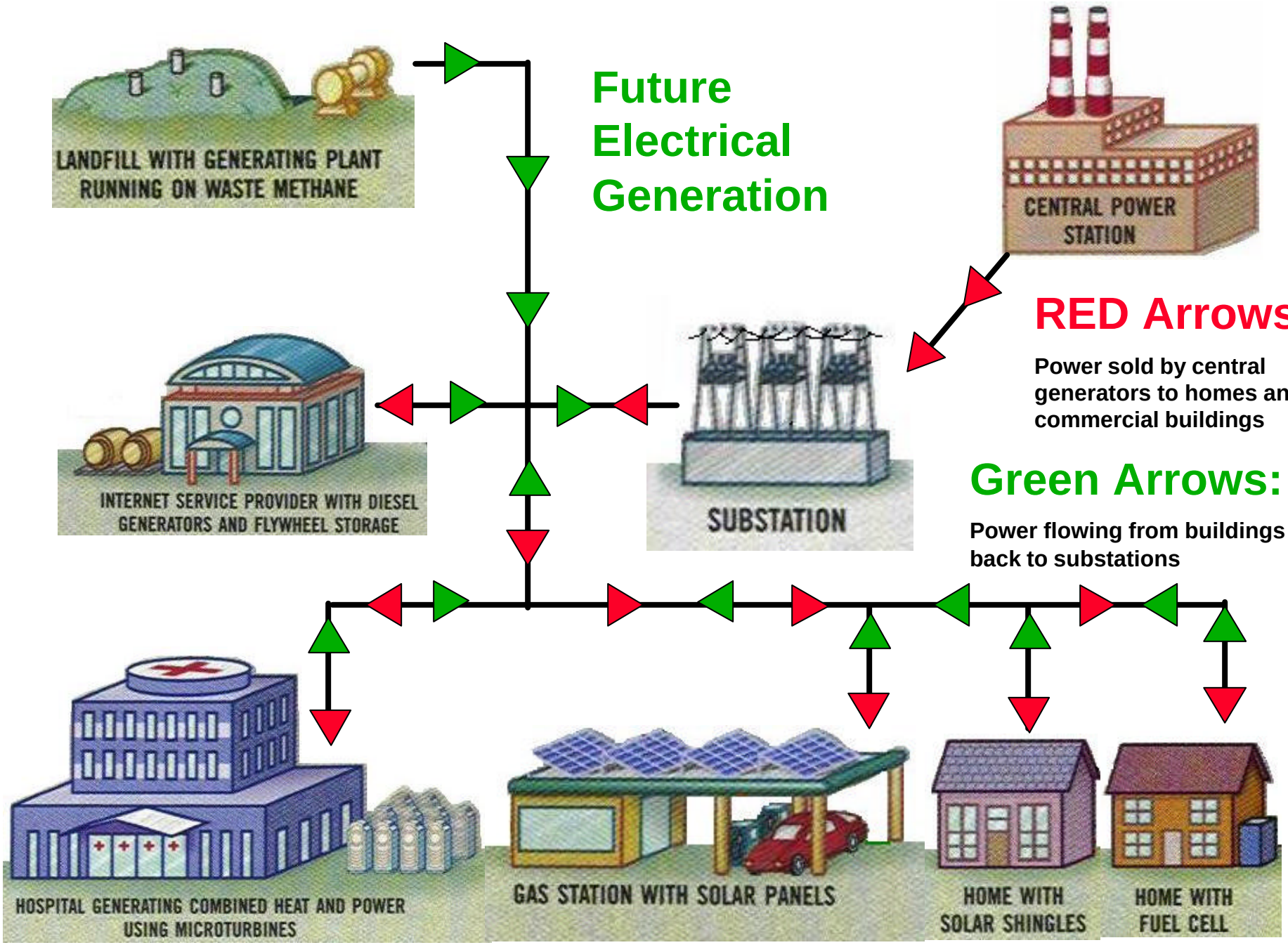
Presented at DOE Distributed Power and Industrial DG Quarterly Review
October 23 – 25, 2001 in Golden Colorado

OUTLINE

- DISTRIBUTED POWER INTERCONNECTION
- INTERCONNECTION BARRIERS
- IEEE P1547 INTERCONNECTION STANDARD STATUS (IEEE -- INSTITUTE of ELECTRICAL and ELECTRONIC ENGINEERS)

DISTRIBUTED POWER

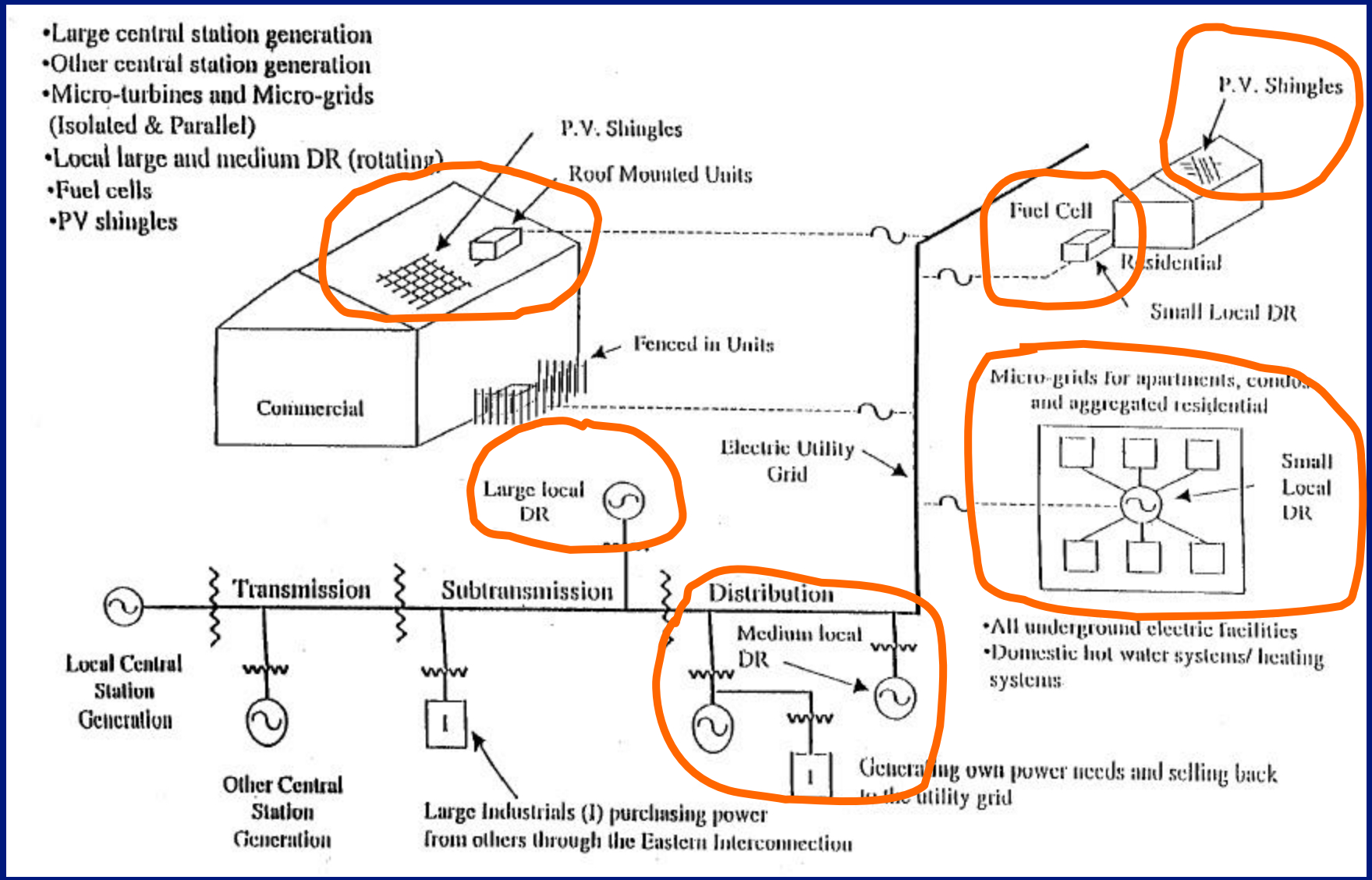
INTERCONNECTION


Future Electrical Generation
LANDFILL WITH GENERATING PLANT RUNNING ON WASTE METHANE
CENTRAL POWER STATION
RED Arrows:
Power sold by central generators to homes and commercial buildings
INTERNET SERVICE PROVIDER WITH DIESEL GENERATORS AND FLYWHEEL STORAGE
SUBSTATION
Green Arrows:
Power flowing from buildings back to substations
HOSPITAL GENERATING COMBINED HEAT AND POWER USING MICROTURBINES
GAS STATION WITH SOLAR PANELS
HOME WITH SOLAR SHINGLES
HOME WITH FUEL CELL

Examples of Distributed Power

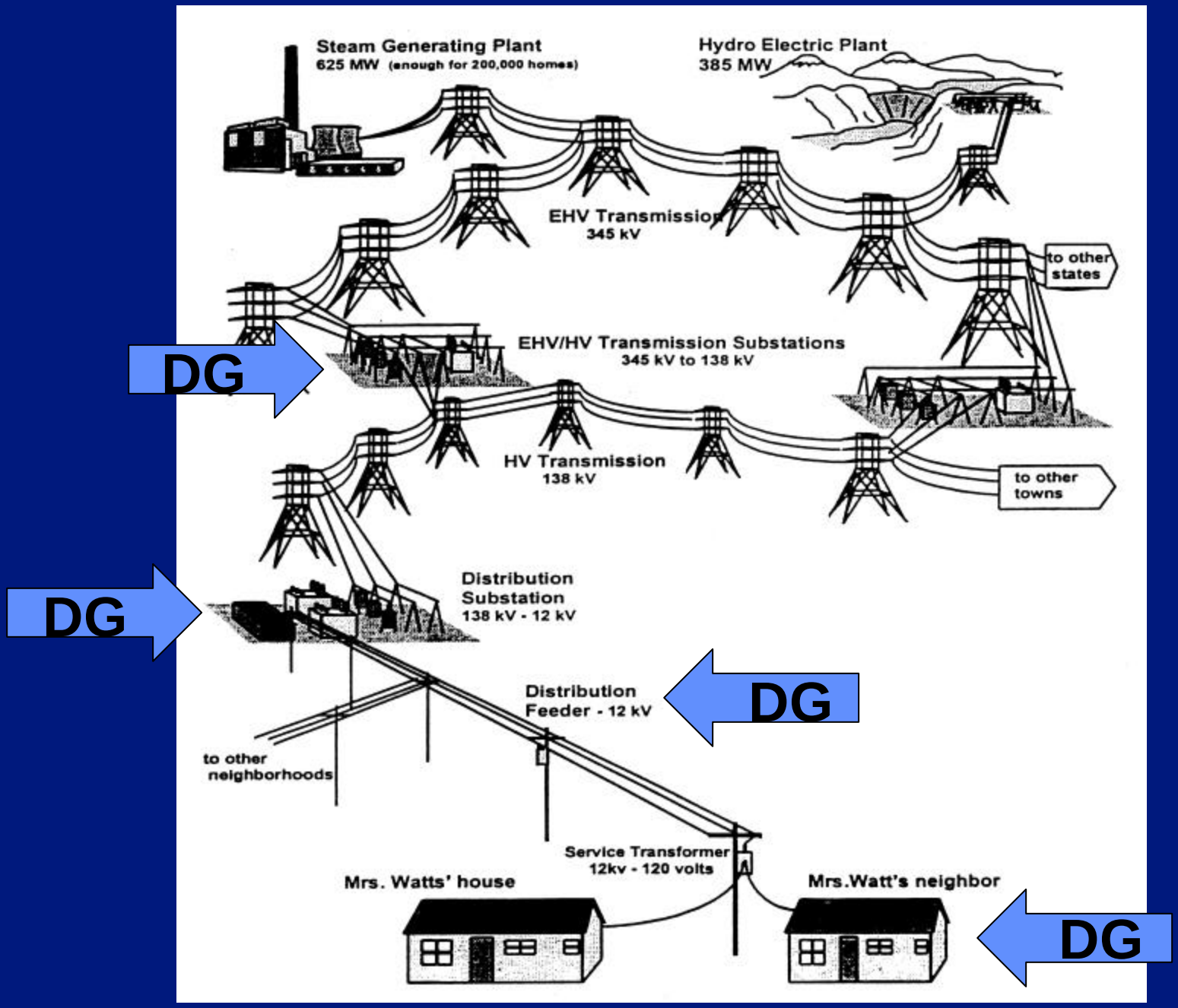
- **Some representative prime mover candidates:**
  - **internal combustion engines**
  - **combustion turbines and microturbines**
  - **Stirling engines**
  - **fuel cells**
  - **photovoltaic solar panels**
  - **small wind turbines**
  - **small biomass power**
- **They use fuels delivered:**
  - **in bulk, e.g., diesel, propane, biomass**
  - **in pipelines, e.g., natural gas**
  - **by nature, e.g., sunshine and wind.**

What might the power system of the future look like?

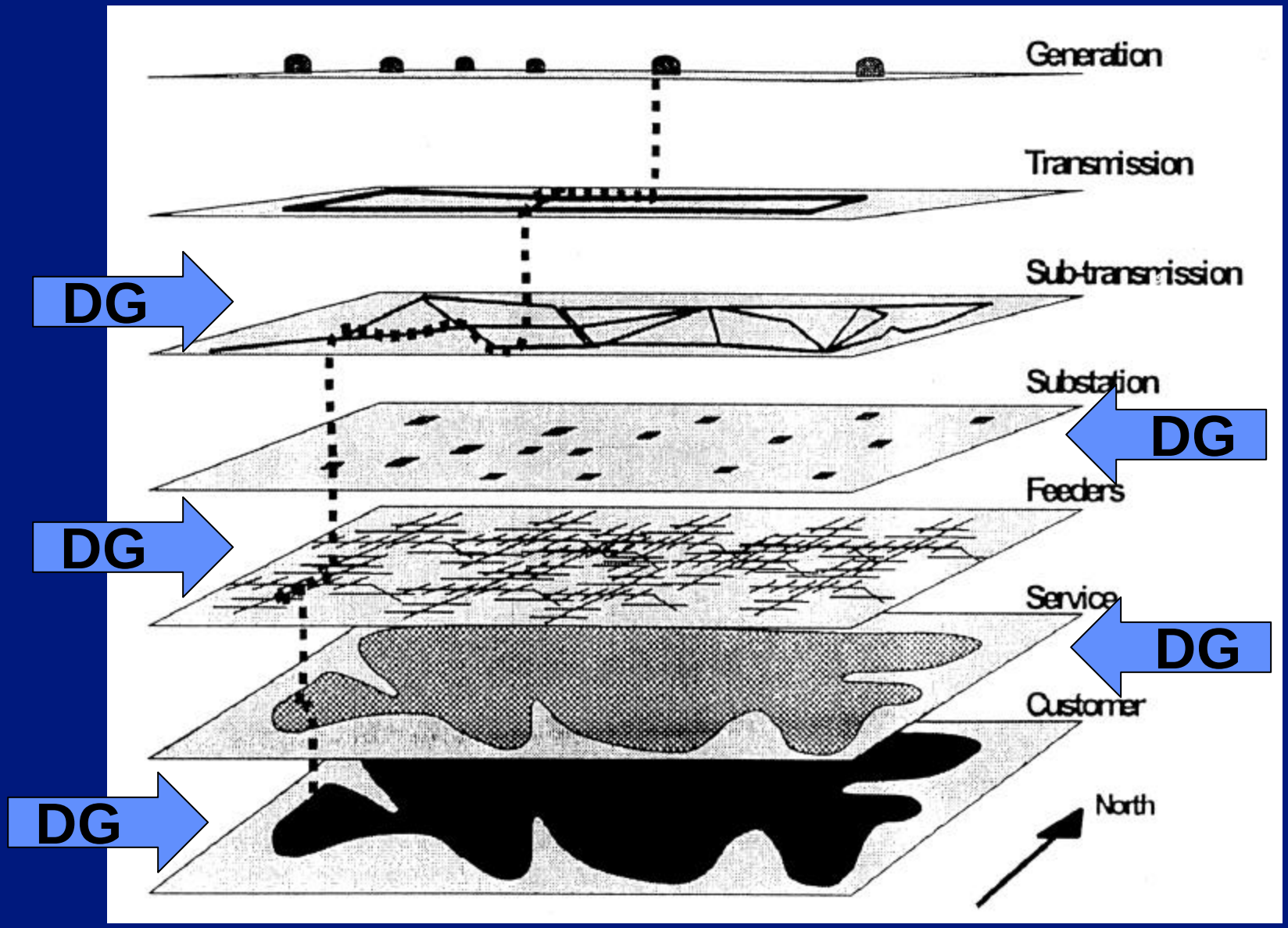


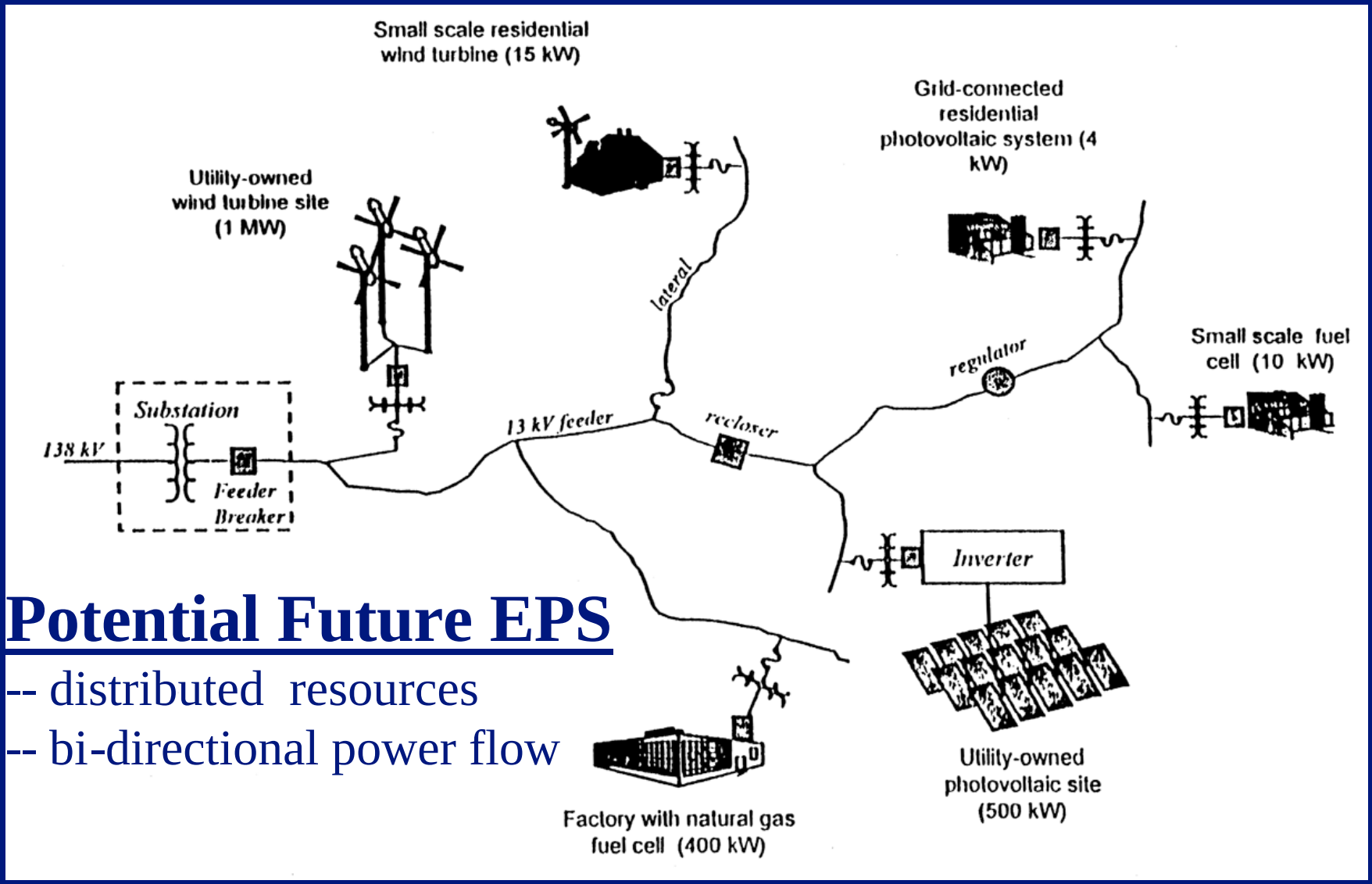
Interconnection
System Integration and Aggregation

- **Vast Operational System**
  - 6,000 to 7,000 Generators
  - 50,000 to 140,000 Transmission Lines
  - 40,000 to 100,000 Substations
  - 130,000,000 End-User Customers
- **Timing and Time Scales**
  - Days to Start Plants to Fractions of Seconds in Automated Responses
- **Human Factors and Education**
  - Behavior


Steam Generating Plant
625 MW (enough for 200,000 homes)
Hydro Electric Plant
385 MW
EHV Transmission
345 kV
to other states
DG
EHV/HV Transmission Substations
345 kV to 138 kV
HV Transmission
138 kV
to other towns
DG
Distribution Substation
138 kV - 12 kV
Distribution Feeder - 12 kV
DG
to other neighborhoods
Service Transformer
12kv - 120 volts
Mrs. Watts' house
Mrs.Watt's neighbor
DG

Layers of Service - Power Gen System



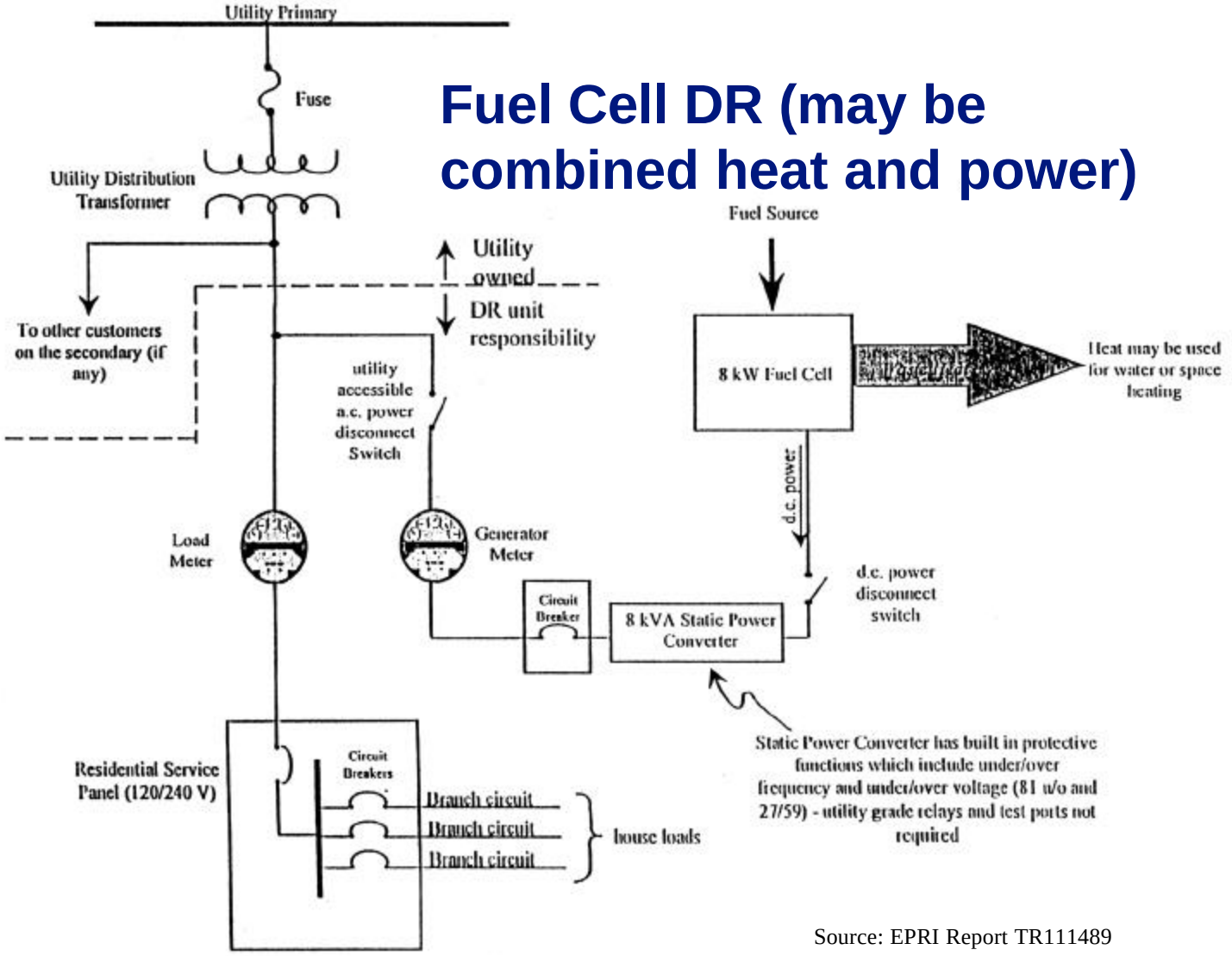


Potential Future EPS

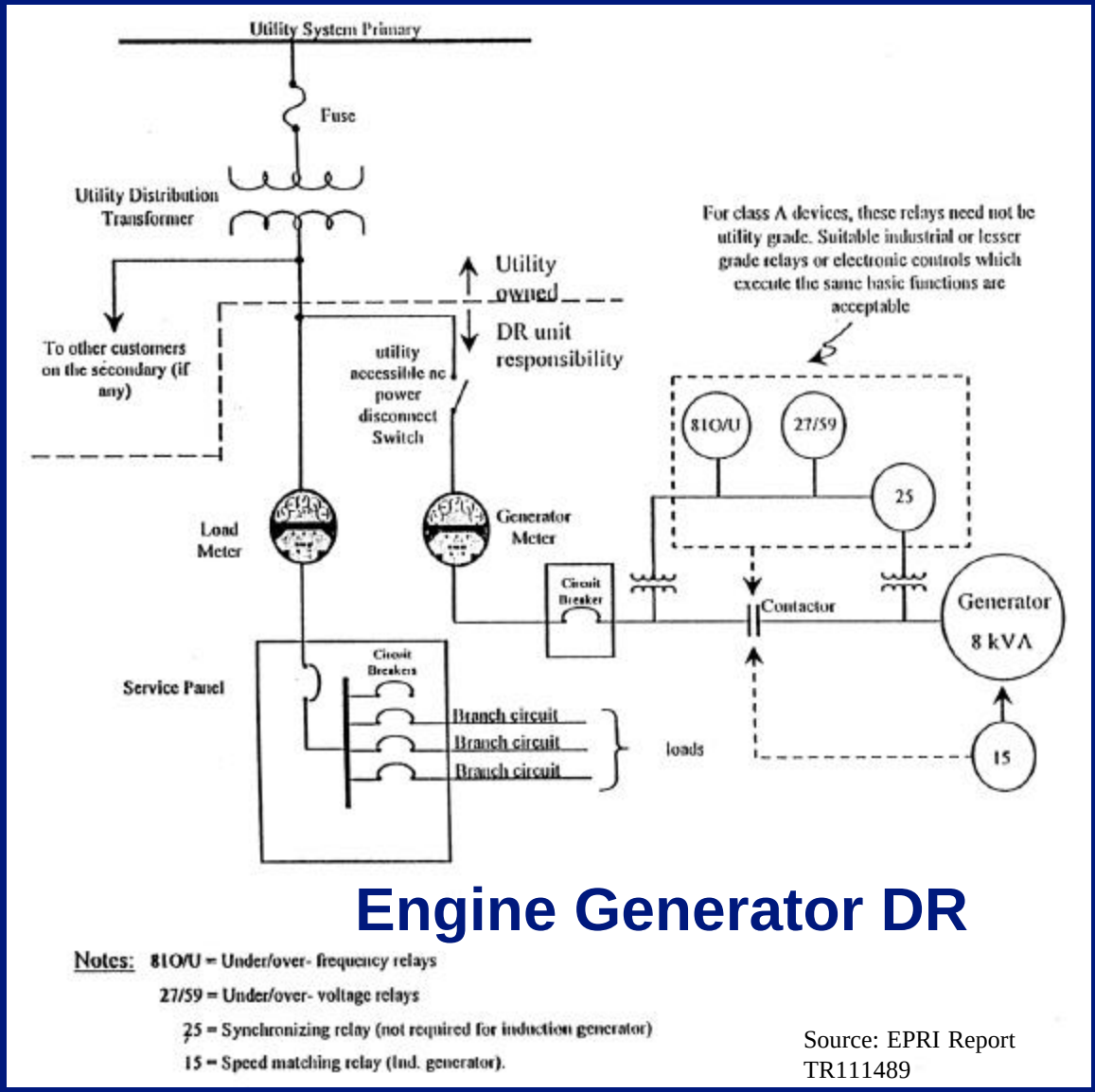
-- distributed resources

-- bi-directional power flow

Fuel Cell DR (may be combined heat and power)



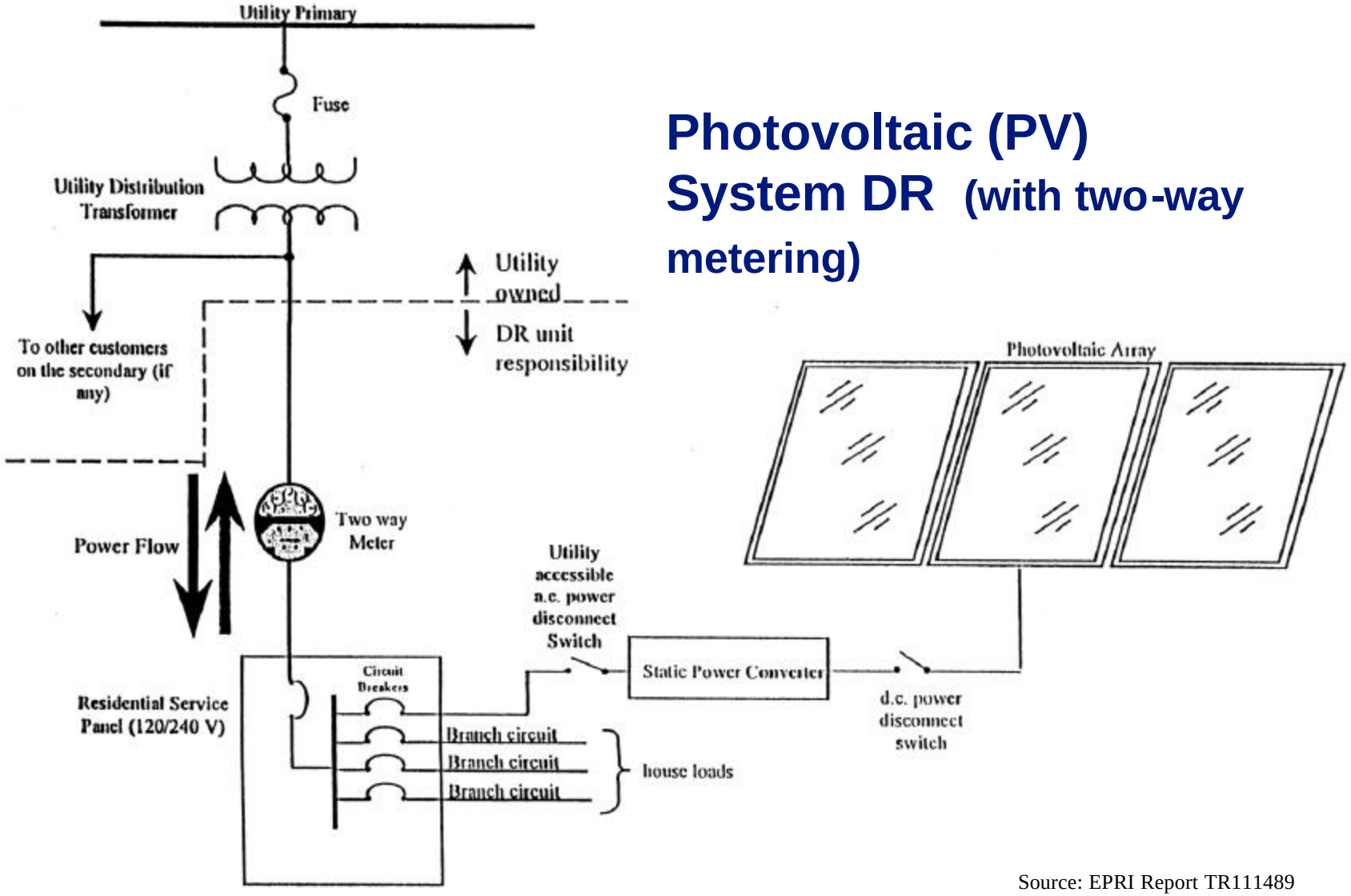
Source: EPRI Report TR111489



Engine Generator DR

Source: EPRI Report TR111489

Photovoltaic (PV) System DR (with two-way metering)

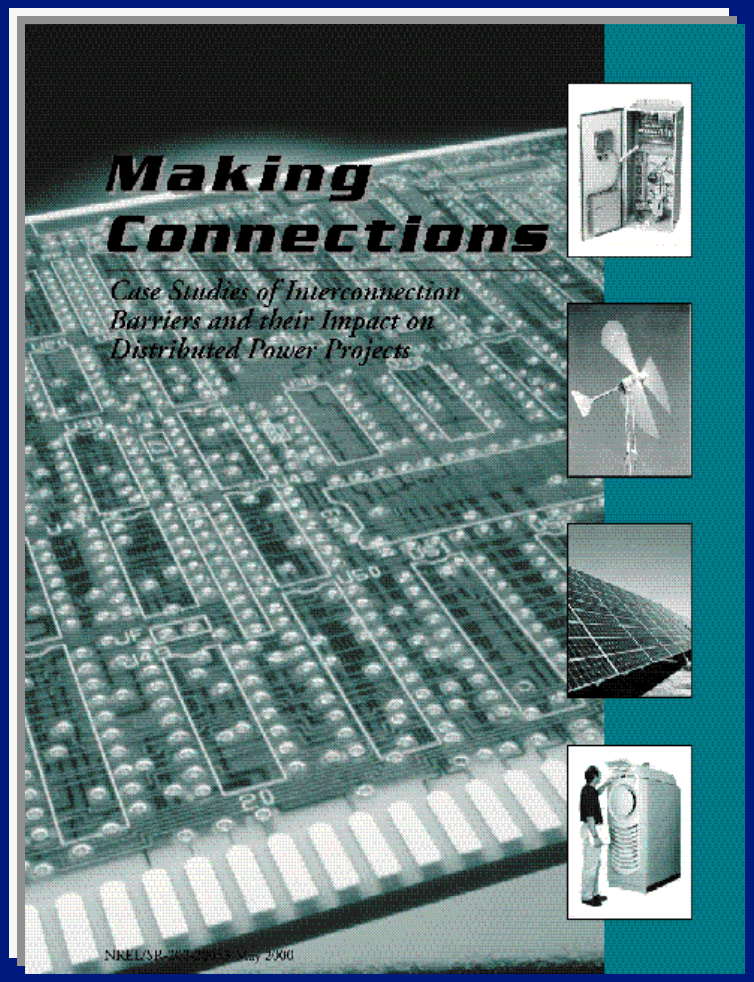


Source: EPRI Report TR111489

INTERCONNECTION

BARRIERS

“Making Connections” Report



- Released May 1, 2000
- Financed and published by DOE/NREL, with support from
- 90 DG projects were identified, 65 surveyed, 26 summarized and included in report
- Projects ranged from 0.3 kW (PV) to 26 MW (gas turbine)
- Available on the Web as PDF file at the following address: http://www.eren.doe.gov/distributedpower/barriersreport/

Making Connections - Ten-Point Action Plan

- **Reduce Technical Barriers**
  - Adopt uniform technical standard for interconnecting distributed power to the grid
  - Adopt testing and pre-certification procedures for DG equipment
  - Accelerate development of distributed power control technology and systems
- **Reduce Business Practice Barriers**
  - Adopt standard commercial practices for any required utility review of interconnection
  - Establish standard business terms for interconnection agreements
  - Develop tools for utilities to assess the value and impact of distributed power at any point on the grid

Making Connections - Ten-Point Action Plan

- **Reduce Regulatory Barriers**
  - **Develop new regulatory principles compatible with distributed power choices in both competitive and utility markets**
  - **Adopt regulatory tariffs and utility incentives to fit the new distributed power model**
  - **Establish expedited dispute resolution processes for distributed generation project proposals**
  - **Define the conditions necessary for a right to interconnect**

Mitigation of Interconnection Barriers

- **Technical requirements for grid interconnection**, e.g., safety and power quality
- **Permitting**, e.g., environmental, building codes, etc.
- **Rules of engagement** for interconnection, e.g., legal, economic, financial and regulatory
- **Obtaining "full value"** for benefits of the distributed power installation.

IEEE P1547

INTERCONNECTION STANDARD STATUS

(IEEE -- INSTITUTE of ELECTRICAL and ELECTRONIC ENGINEERS)

IEEE Interconnection Standard P1547

- **Title:** ***Standard for Interconnecting Distributed Resources with Electric Power Systems***
- **Scope: This standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS).**
- **Purpose: Provide a uniform standard for interconnection of distributed resources with electric power systems, and requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.**
- **Sponsor: IEEE SCC21 --** ***Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage*****; Chair, R. DeBlasio.**

IEEE P1547/D8 Contents

- INTRODUCTION
- 1.0 OVERVIEW
- 2.0 REFERENCES
- 3.0 DEFINITIONS and ACRONYMNS
- 4.0 INTERCONNECTION TECHNICAL
- SPECIFICATIONS AND REQUIREMENTS
- 5.0 TEST SPECIFICATIONS AND REQUIREMENTS
- ANNEXES – INFORMATIVE
  - ANNEX A -- FLICKER INFORMATION
  - ANNEX B -- INTERCONNECTION TESTS
  - ANNEX C -- COMMISSIONING TESTS
  - ANNEX D -- BIBLIOGRAPHY

Technical Requirements Fall Into Several Categories

- General Requirements
- Response to Area EPS Abnormal Conditions
- Power Quality
- Islanding
- Test Specifications and Requirements

Interconnection Concerns Covered in Standard

- Safety
- System and Equipment Protection
- Power Quality and Reliability

P1547 Development Approach

- Voluntary consensus standard
  - Hallmark of the standards process
  - Open to all dedicated parties
  - IEEE ballot member categories:
    - General Interest, Producer, User
- Fast-track schedule
  - April 1999 -- IEEE approved P1547 project
  - March 2001 – Completed initial ballot action
  - October 2001 – Completed recirculation ballot

IEEE P1547 Development Status

- Ballot of Draft 7: Feb. 27 - Mar. 28, 2001
- Re-circulation-ballot of Draft 8 Completed 10/2/01
  - Draft 8: 34 pages of criteria, requirements, and information
  - 167 Ballot members
- P1547 Working Group (WG) at 350 members
- P1547 WG organization
  - R. DeBlasio (NREL) - Chair
  - F. Goodman (EPRI) - Vice Chair
  - J. Koepfinger (Duquesne) -- Vice Chair
  - T. Basso (NREL) -- Secretary
- Meetings every 2 months (started Dec. 1998)
- Last P1547 WG Meeting October 16-19, 2001
  - Draft 7 ballot and Draft 8 recirculation ballot results
  - Prospective new IEEE DR project activities
- P1547 Web site http://grouper.ieee.org/groups/scc21/1547

IEEE P1547 NATIONAL DEBATE BEGINS NATIONAL INTERCONNECTION STANDARD STATUS (Round 1)

- BALLOT ACTION COMPLETED APRIL 1, 2001
- 91% BALLOT RETURNS
- MET THE IEEE 75% RETURN REQUIREMENTS
- ACHIEVED 66% AFFIRMATIVE (NEED 75%)

Voter Category	Affirm	Negative
- User	31	23
- Producer	37	12
- General Interest & Other	30	15

IEEE P1547 NATIONAL DEBATE CONTINUES NATIONAL INTERCONNECTION STANDARD (RECIRCULATION) STATUS (Round 2)

- BALLOT RECIRCULATION COMPLETED OCTOBER 2, 2001
- ACHIEVED 96% BALLOT RETURN
- ACHIEVED 66% AFFIRMATIVE (NEED 75%)
- RESOLUTION OF BALLOTS UNDERWAY
- DRAFT 8 RECIRCULATION To Be Determined

Voter Category	Affirm	Negative
- User	25	33
- Producer	43	6
- General Interest & Other	35	14

IEEE P1547 Interconnection Standard Status

(Requirements for adoption: 75% return, 75% affirmative)

Round 1

- Balloting completed 4/1/01
- 91% ballot returns
- 66% affirmative
- Addressed negative comments

Voter Category	Affirm	Negative
- User	31	23
- Producer	37	12
- General Interest & Other	30	15

Round 2

- Recirculation 10/2/01
- 96% ballot returns
- 66% affirmative
- Draft 8 recirculation TBD

Voter Category	Affirm	Negative
- User	25	33
- Producer	43	6
- General Interest & Other	35	14

SOME KEY ISSUES

- MINIMUM VS MAXIMUM REQUIREMENTS
- FIELD TESTING VS TYPE TESTING
- SECONDARY GRID AND SPOT NETWORKS
- GRID/DG MONITORING AND CONTROL
- VOLTAGE REGULATION/STABILITY
- GROUNDING/FAULTS
- DG PENETRATION/AGGREGATION

Prospective New IEEE DR Activities

DR unit

Interconnection System

- P1547 Draft Std for Interconnection of DR with EPS
- P1589: Interconnection System Testing
- NEW: Guidelines for Communication-Control of DR
- NEW: Guidelines for DR Equipment Certification
- NEW: Application Guide for DR

Area EPS

- NEW: Guidelines for Network Specifications & Applications with DR
- NEW: Recommended Practice for Distributed Generators and Equipment-Specifications and Performance

New IEEE SCC21 Project

IEEE P1589 “Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems”

Approved by the IEEE Standards Board on June 14, 2000

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- **NREL -- http://www.nrel.gov**
- **IEEE SCC21 -- IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, & Energy Storage**
  http://grouper.ieee.org/groups/scc21/
- **P1547 Interconnecting Distributed Resources With Electric Power Systems -- web site and archives**
  http://grouper.ieee.org/groups/scc21/1547
  http://grouper.ieee.org/groups/scc21/1547/archives/
- **DOE Distributed Power Program**
  http://www.eren.doe.gov/distributedpower